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THE DISTRIBUTION OF COBALT-60,
RUTHENIUM-106, AND CESIUM-137 AMONG
SUSPENDED AND DISSOLVED PARTICLES
IN WHITE OAK LAKE

AUTHOR:

William T. Lammers

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RUTHENIUM-106, AND CESIUM-137 AMONG SUSPENDED
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P. O. BOX P, OAK RIDGE, TENNESSEE 37830

January 24, 1969

To: Holders of Union Carbide Corporation, Nuclear Division,
Report Number K-1758

Report Number K-1758, Pages 17 and 18, Table 3

Data presented in the subject report have been reviewed and corrected. Specifically, the value of the Student's "t" parameter has been re-calculated and corrected where necessary.

Please remove and replace the old table with the enclosed corrected table.

Yours sincerely,

A handwritten signature in cursive script, reading "J. W. Amburgey, Jr.".

J. W. Amburgey, Jr.
Biophysical Limnology Laboratory
Separation Systems Division

JWA:egc

Enclosure: Corrected Table 3.

Digest of

Report K-1758

THE DISTRIBUTION OF COBALT-60, RUTHENIUM-106, AND CESIUM-137
AMONG SUSPENDED AND DISSOLVED PARTICLES IN WHITE OAK LAKE

William T. Lammers

Biophysical Limnology Laboratory
Separation Systems Division
Union Carbide Corporation
Nuclear Division
Oak Ridge, Tennessee

Report Date: October 3, 1968

Report Classification: UNCLASSIFIED

White Oak Lake, a small impoundment that receives low level radioactive waste from the operation of the Oak Ridge National Laboratory, was sampled routinely during a 14-month period from November 8, 1966, to January 2, 1968. Each sample was centrifugally fractionated into selected particulate fractions and a dissolved materials fraction. These fractionations, made in the Biophysical Limnology Laboratory, were extracted primarily to determine the feasibility of employing centrifugal techniques for isolating and concentrating waterborne particulate materials for study. In addition, the objective of this study was to establish the relation between quantity, type, and surface- or bio-activity of the particles in a fraction and the accumulation of radionuclides by that fraction.

The fractions isolated from samples of White Oak Lake water were subjected to radiochemical analysis. Linear correlations were calculated for several combinations of the data. From this statistical analysis and interpretation, the pattern of uptake and distribution of three radionuclides (Cobalt-60, Ruthenium-106, and Cesium-137) in the aquatic environment is better understood.

This report contains 20 pages and includes 1 figure and 3 tables.

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Subject Category: WATER POLLUTION
(Distribution: UC-41 and UC-48)

THE DISTRIBUTION OF COBALT-60, RUTHENIUM-106, AND CESIUM-137
AMONG SUSPENDED AND DISSOLVED PARTICLES IN WHITE OAK LAKE

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Report Number: K-1758

Subject Category: WATER POLLUTION

Title: THE DISTRIBUTION OF COBALT-60,
RUTHENIUM-106, AND CESIUM-137
AMONG SUSPENDED AND DISSOLVED
PARTICLES IN WHITE OAK LAKE

Author: William T. Lammers

ABSTRACT

White Oak Lake, a small impoundment that receives low level radioactive waste from the operation of the Oak Ridge National Laboratory, was sampled routinely during a 14-month period from November 8, 1966, to January 2, 1968. Each sample was centrifugally fractionated into selected particulate fractions and a dissolved materials fraction. These fractionations, made in the Biophysical Limnology Laboratory, were extracted primarily to determine the feasibility of employing centrifugal techniques for isolating and concentrating waterborne particulate materials for study. In addition, the objective of this study was to establish the relation between quantity, type, and surface- or bio-activity of the particles in a fraction and the accumulation of radionuclides by that fraction.

The fractions isolated from samples of White Oak Lake water were subjected to radiochemical analysis. Linear correlations were calculated for several combinations of the data. From this statistical analysis and interpretation, the pattern of uptake and distribution of three radionuclides (Cobalt-60, Ruthenium-106, and Cesium-137) in the aquatic environment is better understood.



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THE DISTRIBUTION OF COBALT-60, RUTHENIUM-106, AND CESIUM-137
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INTRODUCTION

A feasibility study on the use of centrifugal techniques for separating waterborne particulate materials was initiated in the fall of 1965, primarily because of its potential application to separating and studying radionuclides contained in natural waters.

The increasing use of nuclear materials for peaceful applications has maintained the need for thorough understanding of the behavior of radionuclides in these environments. The discharge of radioactive materials into the aquatic biosphere makes it possible for low initial levels of radionuclides to be concentrated in certain fractions of the water so a biohazard may be generated (1,2). The information that is needed is not simply the absolute amount of a given radionuclide in a given volume of water, but the distribution of that radionuclide among the various types of particles in that water mass. Knowledge of this will allow meaningful assessment of the potential or actual biohazard (3).

Natural water is a mixture of heterogeneous particles and solutes, of varying surface- and bio-activity, suspended in the solvent water. The more bio-active fractions may accumulate a significant proportion of those radionuclides which are used in biological systems or are biological analogues. Any radionuclides concentrated by a bio-active fraction of the food chain will have an increased potential as a biohazard.

The accumulation of radionuclides by surface-active particles such as organic detritus, minerals, and colloids may compete with bio-active particles for available radionuclides. In some situations this may reduce the biohazard by removing radionuclides from the food chain, in others it may increase the hazard by placing the radionuclides in a position for bio-concentration.

Simplified systems may be simulated in the laboratory, but if it were possible to work with the actual complexities of the environmental situation, one would be closer to understanding the behavior of the contaminant in the environment. This was attempted for suspended organic particles in water during the Clinch River Study (4). However, at that time the techniques for isolation and characterization of particles within a given volume of water were not perfected. Since then, the fractionation and isolation techniques have been improved so it is possible to qualitatively and quantitatively determine the uptake and distribution of a contaminant among the suspended and dissolved fractions of a water mass (5).

As has been reported in previous papers, waterborne particles can be rapidly concentrated and isolated into a number of relatively homogeneous fractions by centrifugal techniques (3,5). A major advantage of this method is particles and contaminants existing in low amounts per unit volume may be recovered from large volume samples so the total quantities

isolated lie within the range of sensitivity of analytical methods. This method of concentration and isolation also causes minimum distortion and injury to particles and minimum loss of accumulated radionuclides. Patchy distribution of particles and seasonal variations in a natural water mass are circumvented by long-term sampling.

SUMMARY

The primary intent of this investigation, in addition to determining feasibility, was to establish the relation between the quantity, type, and surface- or bio-activity of the particles in a fraction and the accumulation of radionuclides by that fraction. This study was made on single samples and over a 14-month period from November 8, 1966, to January 2, 1968.

A 20-liter sample representing water from White Oak Lake was collected monthly in insulated containers and kept below 10°C until completely fractionated. White Oak Lake receives low level radioactive waste from the Oak Ridge National Laboratory. Controlled release is maintained into the Clinch River from this lake. Before dilution in the river, the lake water varies from 3 to 10 times as rich in suspended clay-minerals and plankton as the river. This provided an ideal situation for investigating the distribution and accumulation of specific radionuclides.

Each sample was centrifugally fractionated in the Biophysical Limnology Laboratory according to the scheme outlined in figure 1. The final four fractions were subjected to gamma scans to determine the radioactivity associated with each fraction. These data were summarized and linear correlations were calculated for several combinations of data.

Except for the colloidal fraction, the entire sample was subjected to a statistical analysis and interpretation. From these results the pattern of uptake and distribution of three radionuclides in the entire aquatic environment can be seen, although somewhat vaguely. Future improvements in quantitation should increase the value of the results so more meaningful projections of potential biohazards can be made.

EXPERIMENTAL TECHNIQUES AND RESULTS

In the investigation reported here, the goal was to establish the relation between the quantity, type, and surface- or bio-activity of the particles in a fraction and the accumulation of radionuclides by that fraction. This was done both within a single sample and over the 14-month period from November 8, 1966, to January 2, 1968.

Low level radioactive waste from some of the Oak Ridge laboratories is impounded in White Oak Lake and control-released into the Clinch River. Before dilution in the river, this lake water varied from 3 to 10 times as rich in suspended clay-minerals and plankton as the river. This provides an ideal situation for investigating the distribution and accumulation of specific radionuclides. A 20-liter water sample was collected each month from the spillway of White Oak Dam in an insulated container, and kept below 10°C until fractionation was complete.

The sample was centrifugally fractionated in the Biophysical Limnology Laboratory following the outline shown in figure 1. The particles were isolated from the suspending water by continuous flow centrifugation using a centrifugal impulse (force \times time) sufficient to sediment suspended organic and inorganic particles ($> 20,000$ S) in the first centrifugation (5.6×10^4 g \times min), and organic and inorganic colloids ($< 20,000$ S and > 150 S) in the second (1.44×10^7 g \times min). The $< 20,000$ S [S = sedimentation coefficient in Svedberg units] particles were removed from the rotor and thoroughly resuspended. A linear density gradient of physiologically inert 3,5-DP (methyl glucamine salt of 3,5-diiodo-4-pyridone-N-acetic acid) in a pH 7.2 phosphate buffer was made with a gradient preforming device (6,7). The density range of the gradient was from a minimum of 1 to a maximum of 1.5 g/cc, and a sector-shaped centrifuge tube was used to prevent wall effects during centrifugation (5,8). The suspended $> 20,000$ S particles were carefully layered over the density gradient and then centrifuged to an impulse of 5.6×10^4 g \times min. This separated the organic from the inorganic particles by density differences.

After centrifugation the tube contents were pumped through the flow cell of an optical densiometer and the absorbance of the gradient recorded at 530 m μ . The organic particles, suspended in the gradient, were recovered in a fraction collector and the gradient removed by dialysis against a pH 7.2 phosphate buffer. The chart record area of the gradient absorption peak was measured with a polar planimeter and this value taken as one measure of the quantity of organic material in the $> 20,000$ S fraction. This is a measure of the total amount of suspended organic material, living and dead. A direct count of the organic particles was made using phase contrast microscopy and a Petrof Hausser counting chamber and method. This count generally does not include rare organisms, very small organisms, or organic detritus and is more a measure of the common, intact forms. In the last eight samples the number of viable organic particles was measured by serial dilution, and their rate of growth by turbidity. These values were used in the calculation:

$$C = V/G \times A \quad (1)$$

Where,

V = the number of viable particles,

G = the rate of growth, and

A = the chart record area (5).

The number "C" should reflect both the quantity of total organic material present and the bio-activity of that material.

The $> 20,000$ S inorganic suspended particles pass through the density gradient and form a pellet at the centrifugal side of the centrifuge tube. These particles, chiefly clay-minerals, are recovered by washing them out of the tube with buffer. The number of particles in the inorganic fraction was estimated by the same direct microscope count as for the organic fraction.

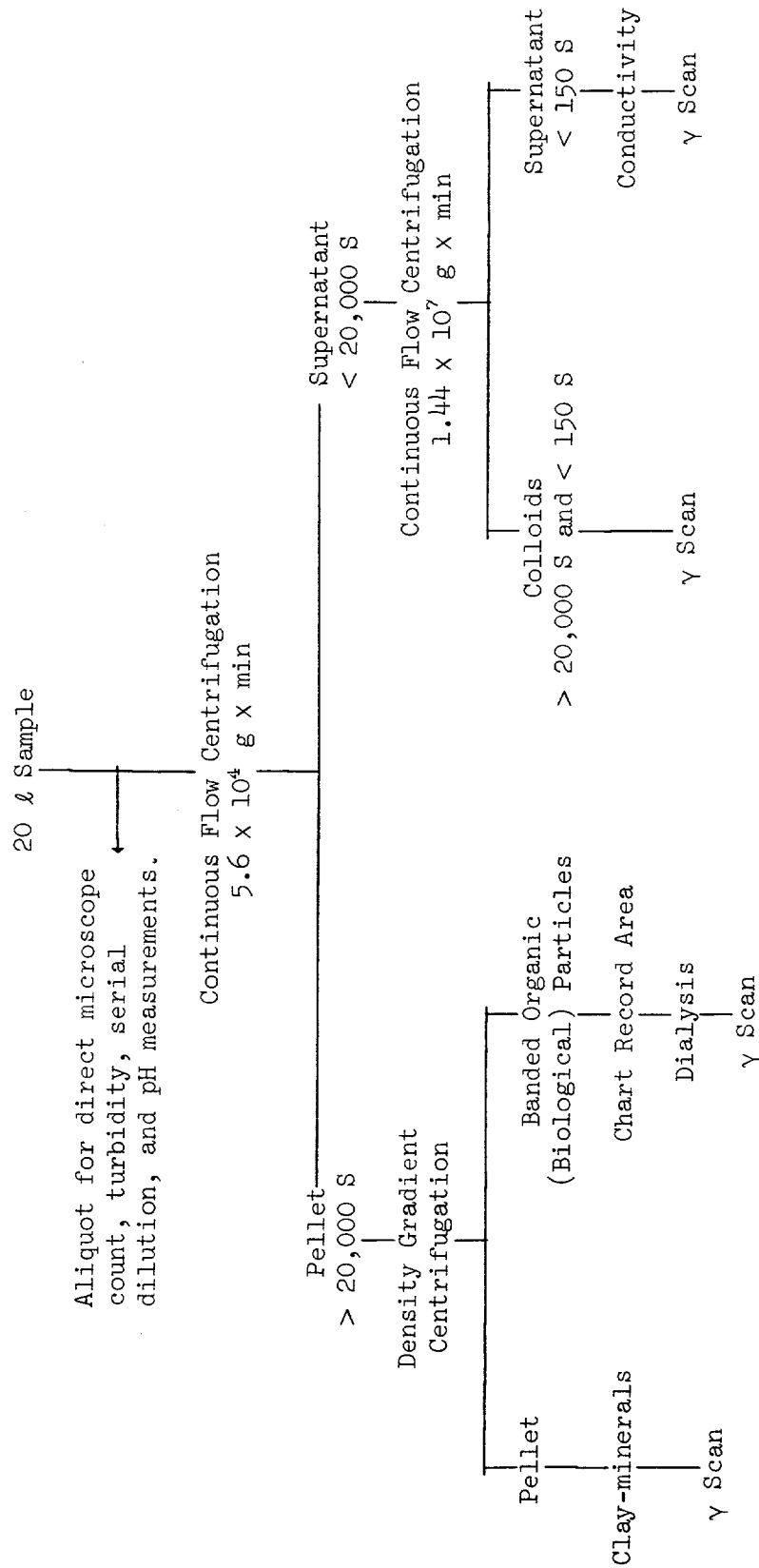


FIGURE 1
 SCHEME OF FRACTIONATION OF A WATER SAMPLE

The colloidal fraction ($< 20,000$ S and > 150 S) from the second continuous flow centrifugation was treated as a single entity, and the centrifugal pellet concentrated to a 50 ml volume by differential centrifugation at a centrifugal impulse of 1.44×10^7 g \times min.

The supernatant from the second continuous flow centrifugation (< 150 S), was concentrated to a 50 ml volume by vacuum evaporation in a 2-l rotary spray evaporator at 35°C flask vapor temperature. The flask contents were removed with washes of 1N HCl and 1N NH_4OH . This fraction is expressed quantitatively as the conductivity of the original supernatant ($\mu\text{mho/cm}$ at 25°C).

The entire fractionation was complete within 30 hours of sample collection. The concentrated fractions were made to a 50 ml volume and subjected to a gamma spectrometer scan for the amount of Co-60, Ru-106, and Cs-137 present. The quantity of each fraction of each sample is shown in table 1. The amount of γ activity of the three radionuclides is shown in table 2.

DATA CORRELATIONS

Linear correlations were calculated for a number of combinations of data using the statement:

$$b = \frac{\sum xy - \frac{(\sum x)(\sum y)}{N}}{\sum x^2 - \frac{(\sum x)^2}{N}} \quad (2)$$

$$\text{and } \tilde{y} = \bar{y} + b(x - \bar{x}) \quad (9) \quad (3)$$

$$= bx + (\bar{y} - b\bar{x}) \equiv bx + c \quad (4)$$

Where x = the fraction quantity,

y = picocuries of γ activity,

N = number of samples or fractions,

\bar{x} of \bar{y} = mean of samples or fractions, and

\tilde{y} = true value of y .

From equations (3) and (4) the regression line can be plotted. The values of N , b , and c are given in table 3.

The regression coefficient, r , of a linear correlation was calculated for the above values from the statement:

TABLE 1

QUANTITY OF EACH FRACTION OF A SAMPLE

Sample Date	OM Count	OM Area	"C"	IOM Count	μ mho	pH	Temp, °C
11/7/66	9.7×10^8	1.875	--	1.01×10^9	273	7.84	14
12/19	6.3×10^8	4.87	--	2.8×10^8	281	8.65	10
1/24/67	1.5×10^8	2.27	--	2.6×10^8	284	8.63	14
2/13	2.9×10^8	5.02	--	5×10^8	270	7.06	9
4/10	1.8×10^8	11.02	--	1.5×10^8	284	8.13	21
5/1	2.41×10^8	4.24	--	6.9×10^8	248	8.34	20
6/19	2.7×10^8	3.91	1480	2.1×10^8	273	8.35	26
6/28	9.6×10^8	22.8	731	1.62×10^9	178	7.31	23
7/24	2.1×10^8	2.57	299	1.9×10^8	261	8.51	25
8/29	1.1×10^7	1.56	4578	8×10^6	270	8.53	18
9/25	6.78×10^7	1.32	20	6.5×10^8	310	8.63	19
10/30	1.5×10^8	1.65	1021	8×10^7	310	8.09	13
12/12	1×10^7	1.6	42	7×10^7	179	7.71	15
1/2/68	3×10^7	1.2	48	9×10^7	220	7.90	9

OM Count = direct microscope count of organic (biological) particles/ml.
 OM Area = chart record area of suspended organic particles in the density gradient.

"C" = value of $V/G \times A$ for suspended organic particles.

IOM Count = direct microscope count > 20,000 S clay-mineral particles.

μ mho = conductivity of water sample in μ mho/cm at 25°C.

pH = pH of water sample at the time of sampling.

Temp = water sample temperature at the time of sampling.

TABLE 2, PART A

γ ACTIVITY OF EACH FRACTION OF A SAMPLE
COBALT

Sample Date	OM Co-60	IOM Co-60	> 150 S Co-60	< 150 S Co-60	Total Co-60
11/7/66	0 ± 24	318 ± 40	0 ± 24	5960 ± 65	6280 ± 65
12/19	3 ± 24	224 ± 24	9 ± 24	3730 ± 74	3967 ± 74
1/24/67	0 ± 24	372 ± 40	17 ± 24	6040 ± 100	6421 ± 100
2/13	0 ± 24	202 ± 30	3 ± 24	680 ± 61	885 ± 61
4/10	7 ± 24	415 ± 41	16 ± 24	2433 ± 45	2871 ± 45
5/1	1 ± 24	112 ± 24	16 ± 24	4221 ± 105	4350 ± 105
6/19	9 ± 24	131 ± 24	18 ± 24	569 ± 35	729 ± 35
6/28	0 ± 24	323 ± 50	0 ± 24	2364 ± 75	2687 ± 75
7/24	0 ± 24	923 ± 35	43 ± 24	1149 ± 60	2120 ± 60
8/29	0 ± 24		0 ± 24	3025 ± 300	
9/25	0 ± 24		12 ± 24	166 ± 30	
10/30	16 ± 24	301 ± 30	8 ± 24	484 ± 50	809 ± 50
12/12	5 ± 24		38 ± 24	1806 ± 65	
1/2/68	4 ± 24		20 ± 24	2192 ± 150	

Activity is in pico curies.

OM = the suspended particles > 20,000 S and with a density < 1.4 g/cc.

IOM = the suspended particles > 20,000 S and with a density > 1.4 g/cc.

> 150 S = the colloidal particles < 20,000 S and > 150 S.

< 150 S = the supernatant from the last centrifugation.

TABLE 2, PART B
RUTHENIUM ACTIVITY

<u>Sample Date</u>	<u>OM Ru-106</u>	<u>IOM Ru-106</u>	<u>> 150 S Ru-106</u>	<u>< 150 S Ru-106</u>	<u>Total Ru-106</u>
11/7/66	0 ± 40	372 ± 60	20 ± 40	14050 ± 200	14444 ± 200
12/19	0 ± 40	91 ± 40	37 ± 40	8640 ± 124	8772 ± 124
1/24/67	0 ± 40	585 ± 50	74 ± 40	12550 ± 460	13217 ± 460
2/13	0 ± 40	328 ± 46	26 ± 40	14950 ± 150	14307 ± 150
4/10	27 ± 40	404 ± 45	87 ± 40	4996 ± 123	6314 ± 123
5/1	5 ± 40	329 ± 40	75 ± 40	7548 ± 213	7957 ± 213
6/19	4 ± 40	334 ± 40	64 ± 40	3110 ± 100	3519 ± 100
6/28	93 ± 40	204 ± 45	127 ± 40	6850 ± 200	7274 ± 200
7/24	0 ± 40	202 ± 50	222 ± 40	2700 ± 90	3149 ± 90
8/29	0 ± 40		0 ± 40	8177 ± 654	
9/25	0 ± 40		32 ± 40	923 ± 150	
10/30	0 ± 40	513 ± 58	61 ± 40	1271 ± 86	1845 ± 86
12/12	15 ± 40		46 ± 40	2830 ± 150	
1/2/68	0 ± 40		4 ± 40	2364 ± 200	

TABLE 2, PART C

CESIUM ACTIVITY

<u>Sample Date</u>	<u>OM Cs-137</u>	<u>IOM Cs-137</u>	<u>> 150 S Cs-137</u>	<u>< 150 S Cs-137</u>	<u>Total Cs-137</u>
11/7/66	0 ± 15	945 ± 50	6 ±	1017 ± 60	1983 ± 60
12/19	7 ± 15	891 ± 40	6 ±	754 ± 53	1659 ± 50
1/24/67	0 ± 15	1125 ± 60	18 ±	191 ± 40	1336 ± 60
2/13	4 ± 15	1040 ± 45	31 ±	733 ± 41	1811 ± 45
4/10	9 ± 15	1621 ± 61	17 ±	649 ± 39	2296 ± 60
5/1	0 ± 15	321 ± 19	37 ±	986 ± 45	1344 ± 45
6/19	11 ± 15	660 ± 40	43 ±	895 ± 50	1614 ± 50
6/28	10 ± 15	3415 ± 163	45 ±	11 ± 15	3481 ± 160
7/24	0 ± 15	767 ± 60	44 ±	629 ± 50	1445 ± 60
8/29	7 ± 15		8 ±	1392 ± 150	
9/25	8 ± 15		39 ±	425 ± 56	
10/30	13 ± 15	1537 ± 60	108 ±	680 ± 40	2338 ± 60
12/12	2 ± 15		26 ±	334 ± 40	
1/2/68	43 ± 15		55 ±	1158 ± 100	

$$r^2 = \frac{\left[\sum xy - \frac{(\sum x)(\sum y)}{N} \right]^2}{\left[\sum x^2 - \frac{(\sum x)^2}{N} \right] \left[\sum y^2 - \frac{(\sum y)^2}{N} \right]} \quad (5)$$

The value of Student's "t" was calculated using the statement:

$$t = \sqrt{\frac{r^2(N-2)}{1-r^2}} \quad (6)$$

The values of r and t are shown in table 3.

An interpretation of the results where the value of r is > 0.5 is that if, (1) the quantity of the fraction shows a + correlation with the quantity of the radionuclide accumulated by that fraction, but not with the total amount of that radionuclide in the entire sample, then the fraction actively accumulated that radionuclide, but does not efficiently compete for it with other fractions. If, (2) the quantity of the fraction shows a + correlation with the quantity of the total amount of a radionuclide in the entire sample, but a low correlation with the quantity of the radionuclide accumulated by that fraction, then it is an efficient, active competitor, but not efficient enough to become saturated. If, (3) the quantity of the fraction shows a + correlation with both the total amount of the radionuclide in the sample and with the amount in that fraction, then the fraction is efficient both in accumulating and competing for the specific radionuclide and can probably accumulate it at the expense of other fractions. If, (4) there is no correlation between the fraction and the radionuclide, then it is probably a passive absorber, or other factors control its behavior. Each of the first three types probably involves either surface- or bio-activity, or both, and all of the fractions examined can be reasonably assigned to one of the four classes. Lack of a correlation does not necessarily mean that a fraction is not highly radioactive, but that the rate of accumulation cannot be predicted from the available data. One should not lose sight of the fact that most of the total activity of the radionuclides Co-60 and Ru-106 is in the dissolved fraction (< 150 S), and that most of the total activity of Cs-137 is in the clay-mineral fraction.

The suspended inorganic fraction shows a type 3 correlation with Cs-137, but none with either Ru-106 or Co-60. The < 150 S fraction shows a type 1 correlation with Ru-106 and a type 2 correlation with Cs-137, but none with Co-60. The < 20,000 S and > 150 S colloidal fraction was not quantitated so no statistical calculations were made with it.

Three sets of computations were made with the organic fraction. The chart record area (a) represents the total organic material in the suspended particle range. The direct count (b) represents the intact, larger particles. The value of C (c) represents the relation of the total number or volume of, particles, the number alive, and the bioactivity. The chart record area (a) shows a type 2 correlation with Co-60, a type 3 correlation with Ru-106, but no correlation with Cs-137. The direct count (b) shows a type 1 correlation with Ru-106 and a type 2 correlation with Cs-137, but no other correlations. The value of C (c) shows type 2 correlations

TABLE 3

LINEAR CORRELATION DATA

<u>X</u>	<u>Y</u>	<u>N</u>	<u>b</u>	<u>c</u>	<u>t</u>	<u>r</u>
OM Area	OM Ru-106	14	0.41	-0.90	0.11	0.95
OM Area	Total Ru-106	10	-0.58	0.85	0.22	0.78
OM Area	OM Cs-137	14	-0.33	0.83	0.61	0.18
OM Area	Total Cs-137	10	0.84	0.14	0.43	0.84
OM Area	OM Co-60	14	-0.94	0.37	0.40	0.12
OM Area	Total Co-60	10	-0.43	0.34	0.38	0.13
C	OM Ru-106	8	-0.25	0.17	0.29	0.12
C	Total Ru-106	4	-0.23	0.32	0.21	0.83
C	OM Cs-137	8	-0.15	0.13	0.44	0.18
C	Total Cs-137	4	-0.11	0.23	0.87	0.61
C	OM Co-60	8	-0.30	0.46	0.19	0.79
C	Total Co-60	4	-0.15	0.29	0.17	0.76
OM Count	OM Ru-106	14	0.40	-0.12	0.21	0.51
OM Count	Total Ru-106	10	0.53	0.61	0.11	0.36
OM Count	OM Cs-137	14	-0.79	0.94	0.82	0.24
OM Count	Total Cs-137	10	0.11	0.15	0.19	0.55
OM Count	OM Co-60	14	-0.31	0.43	0.76	0.22
OM Count	Total Co-60	10	0.24	0.22	0.11	0.37
IOM	IOM Ru-106	10	-0.90	0.38	0.87	0.30
IOM	Total Ru-106	10	0.33	0.65	0.10	0.33
IOM	IOM Cs-137	10	0.11	0.70	0.21	0.60
IOM	Total Cs-137	10	0.84	0.15	0.29	0.63

TABLE 3

LINEAR CORRELATION DATA, Continued

<u>X</u>	<u>Y</u>	<u>N</u>	<u>b</u>	<u>c</u>	<u>t</u>	<u>r</u>
IOM	IOM Co-60	10	-0.87	0.38	0.53	0.18
IOM	Total Co-60	10	0.11	0.25	0.77	0.26
μmho	μmho Ru-106	14	0.95	0.41	0.29	0.83
μmho	Total Ru-106	10	-0.58	0.97	0.12	0.43
μmho	μmho Cs-137	14	0.23	0.10	0.90	0.25
μmho	Total Cs-137	10	-0.11	0.47	0.19	0.57
μmho	μmho Co-60	14	-0.20	0.30	0.15	0.42
μmho	Total Co-60	10	-0.15	0.35	0.71	0.25
IOM	μmho	10	-0.62	0.30	0.47	0.86
IOM Count	IOM Dry Weight	5	-0.15	0.19	0.95	0.48
μmho	C	8	0.81	0.24	0.60	0.24
μmho	OM Area	14	-0.32	0.28	0.17	0.45
OM Count	C	8	-0.40	0.11	0.21	0.83
OM Count	OM Area	14	0.79	0.24	0.18	0.47

OM Area = chart record area of the density gradient.

C = value of $V/G \times A$ for suspended organic particles.

OM Count = direct microscope count of organic particles/ml.

IOM Count = direct microscope count of clay-mineral particles/ml.

μmho = conductivity of water sample in $\mu\text{mho/cm}$ at 25°C .

TABLE 3

LINEAR CORRELATION DATA

<u>X</u>	<u>Y</u>	<u>N</u>	<u>b</u>	<u>c</u>	<u>t*</u>	<u>r</u>
OM Area	OM Ru-106	14	0.41	-0.90	11.	0.95
OM Area	Total Ru-106	10	-0.58	0.85	3.5	0.78
OM Area	OM Cs-137	14	-0.33	0.83	0.61	0.18
OM Area	Total Cs-137	10	0.84	0.14	4.3	0.84
OM Area	OM Co-60	14	-0.94	0.37	0.40	0.12
OM Area	Total Co-60	10	-0.43	0.34	0.38	0.13
C	OM Ru-106	8	-0.25	0.17	0.29	0.12
C	Total Ru-106	4	-0.23	0.32	2.1	0.83
C	OM Cs-137	8	-0.15	0.13	0.44	0.18
C	Total Cs-137	4	-0.11	0.23	1.1	0.61
C	OM Co-60	8	-0.30	0.46	3.2	0.79
C	Total Co-60	4	-0.15	0.29	1.7	0.76
OM Count	OM Ru-106	14	0.40	-0.12	2.1	0.51
OM Count	Total Ru-106	10	0.53	0.61	1.1	0.36
OM Count	OM Cs-137	14	-0.79	0.94	0.86	0.24
OM Count	Total Cs-137	10	0.11	0.15	1.9	0.55
OM Count	OM Co-60	14	-0.31	0.43	0.76	0.22
OM Count	Total Co-60	10	0.24	0.22	1.1	0.37
IOM	IOM Ru-106	10	-0.90	0.38	0.87	0.30
IOM	Total Ru-106	10	0.33	0.65	1.0	0.33
IOM	IOM Cs-137	10	0.11	0.70	2.1	0.60
IOM	Total Cs-137	10	0.84	0.15	2.3	0.63

TABLE 3

LINEAR CORRELATION DATA, Continued

<u>X</u>	<u>Y</u>	<u>N</u>	<u>b</u>	<u>c</u>	<u>t*</u>	<u>r</u>
IOM	IOM Co-60	10	-0.87	0.38	0.53	0.18
IOM	Total Co-60	10	0.11	0.25	0.77	0.26
μ mho	μ mho Ru-106	14	0.95	0.41	5.2	0.83
μ mho	Total Ru-106	10	-0.58	0.97	1.3	0.43
μ mho	μ mho Cs-137	14	0.23	0.10	0.90	0.25
μ mho	Total Cs-137	10	-0.11	0.47	1.9	0.57
μ mho	μ mho Co-60	14	-0.20	0.30	1.6	0.42
μ mho	Total Co-60	10	-0.15	0.35	0.71	0.25
IOM	μ mho	10	-0.62	0.30	4.7	0.86
IOM Count	IOM Dry Weight	5	-0.15	0.19	0.95	0.48
μ mho	C	8	0.81	0.24	0.60	0.24
μ mho	OM Area	14	-0.32	0.28	1.7	0.45
OM Count	C	8	-0.40	0.11	3.6	0.83
OM Count	OM Area	14	0.79	0.24	1.8	0.47

OM Area = chart record area of the density gradient.

C = value of $V/G \times A$ for suspended organic particles.

OM Count = direct microscope count of organic particles/ml.

IOM Count = direct microscope count of clay-mineral particles/ml.

μ mho = conductivity of water sample in μ mho/cm at 25°C.

* Corrected value based on the Student "t" equation.

for Ru-106 and Cs-137, and type 3 for Co-60. These may be interpreted to mean that the uptake of Ru-106 by the organic fraction depends more on the increasing surface area or volume of the fraction than on bio-activity. On the other hand, accumulation of Co-60 and Cs-137 probably depends on both surface- and bio-activity. The value of C should give the best single estimate of the behavior of this organic fraction.

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